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ABSTRACT

A study was conducted in Kansas to determine the need for vocational education programs in solar energy technology in community colleges. After a literature search revealed a project need for trained solar energy technicians, Seward County Community College surveyed 100 Kansas heating, air conditioning, and plumbing companies to determine future personnel demand in the solar industry. (An assumption was made that the heating, air conditioning, and plumbing category would be the most likely to become involved in the solar industry.) From the responses of the firms that answered the survey, a projection was made for the state's 1,345 plumbing, heating, and cooling contractors; it was deduced that 1,560 solar-trained people would be needed in Kansas in the next ten years. Based on another study conducted by Navarro College, it was concluded that community colleges should address three levels of educational competency in the solar technology field: first, continuing education programs and seminars to upgrade conventionally-trained heating, ventilating, and air conditioning (HVAC) technicians in solar applications; second, a program to train students in conventional HVAC subjects as well as solar to work primarily as solar installers/mechanics; third, a two-year associate degree program to train solar technicians as diagnosticians, or para-professionals, in the solar field. The document includes task analysis for the design, installation, and maintenance of a solar system; performance objectives for curriculum development; and a list of resources. (KC)

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KANSAS SOLAR TECHNOLOGY MANPOWER TRAINING STUDY

The development of solar energy as a workable means of maintaining our technological society in a competitive posture through national energy self-sufficiency is a goal the United States is now pursuing. The community colleges throughout the country, because of the accessibility and service to the spectrum of the nation's population, can make a contribution to the solar industry by training the necessary manpower to insure that solar will become an integral part of our nation's energy program.

The objective of this study is to determine the need for a vocational education program in solar energy technology that will be used to train persons in utilization of solar energy and solar energy mechanisms as a source of power for commercial and residential use.

Too often, education has not been able to supply, upon demand, a trained labor force for new and emerging technologies. However, frequently, education continues to produce trainees for particular occupations long after the personnel needs have been fulfilled. Therefore, the role of education is to interact to a greater extent with industry and to become alert to the labor market so that proper synchronization between supply and demand can be achieved.

Literature points out that solar has a very definite role as an alternative source of energy in the future of the United States. The role of the sun as a direct source of energy is in its beginning stages, but it can make a significant impact on our energy shortages in the next ten years if conditions are present to bring it into the mainstream of our energy resources. A paramount factor in the success of solar heating and cooling as an alternative energy source is trained manpower.

The confidence in the technical capability of solar to make a major contribution to the energy need of our society is maturing. The technology is available in solar today to make that needed contribution. The economic aspect of the issue is a direct relationship to mass production and skilled manpower availability. Therefore, the economics of solar poses a major deterent to the broad scale utilization of this resource.

The community colleges throughout Kansas and the nation can be instrumental in alleviating one aspect of the economic constraints--trained manpower.

The extent of the use of solar energy technology will depend on market acceptance of solar energy equipment. Nevertheless, a substantial national commitment has been made by the U.S. Congress to increase use of solar. Such a commitment, coupled with rising fossil fuel costs, leads to the

conclusion that need will exist for skilled workers and technicians even though the extent of the need is still unknown.

If implementation of solar energy is to be achieved, a skilled pool of workers must be trained to install, maintain, and service solar devices. This is an initial step, in view of the developed state of the arts, toward public acceptance which is mandatory for success of this emerging industry.

RESEARCH

The immediate need for trained solar manpower has been indicated by reviewing the solar installation projections made by three prominent studies listed below:

1. AN ECONOMIC ANALYSIS OF SOLAR WATER AND SPACE HEATING. A study by the MITRE Corporation, July, 1977.
2. SOLAR MARKET CAPTURE AND MARKET PENETRATION, by Sheldon Butt. A study by the Solar Energy Industries Association (SEIA), October, 1976.
3. THE ECONOMICS OF SOLAR HOME HEATING, by William D. Schulze, Shaul Ben-David. A study by the University of New Mexico, July, 1976.

The SEIA study is the industries own estimate of its market potential. As such, it represents the views of those who most directly gain or lose depending on the accuracy of their perception.

The MITRE study is the product of the most intense effort by DOE. to date, to arrive at feasibility and market penetration estimates. MITRE estimates are being used extensively by DOE in many other analyses.

The University of New Mexico study (UNM Study) forecasts the economic feasibility of solar energy state-by-state, by year, and by application.

The solar manpower forecast made in the DOE study, as a direct function of equipment market projections, indicates the following pattern of development:

1. At least 2.4 million solar units will be installed in the United States by 1985.
2. There must be a minimum of 25,000 skilled workers in the solar field by 1985.
3. Four-fifths, or 20,000, of the solar workers must be trained at the installer/mechanics level.
4. One-fifth, or 5,000, of the solar workers must be trained at the solar technician level.
5. Training for both the solar technician and the solar installer/mechanic can be accomplished at the community college level, the solar technician program being an associate degree two year curriculum, and the solar installer/mechanic program being a certificate of completion program.

From March through June, 1980, Seward County Community College surveyed 100 Kansas heating, air conditioning and plumbing companies to determine future manpower demand in the solar industry. These businesses were identified by random selection from Kansas telephone directories. An original assumption was made that the heating, air conditioning and plumbing category would be the most likely category to consider becoming involved in the solar industry.

Of the 100 questionnaires sent out, 10 were returned as undeliverable. Of the 90 remaining questionnaires, a total of 30 were mailed back by respondents. This resulted in an overall return rate of 30%, which is very reasonable in relation to nationwide averages for response to questionnaires of random type.

The categories included in the study were solar installers and solar technicians.

The solar installer/mechanic, is defined as a tradesperson who has knowledge of solar systems and is expected to perform entry level tasks of installation and routine maintenance. A program to train solar installers/mechanics who have no trade experience or training would include conventional heating, ventilating, and air conditioning and plumbing training, as well as solar skill knowledge. This program can be handled in a one year certificate program.

The solar technician is defined as a person responsible for the design of a solar energy system. The technician is also responsible for overall system checkout and for trouble-shooting in case of repair. This person is expected to have adequate knowledge and skills to perform solar related tasks of relative sophistication. The education necessary for a solar technician exceeds that of a typical tradesman and is beyond the requirements of a solar installer/mechanic.

A copy of the survey card sent randomly to 100 Kansas heating, air conditioning and plumbing businesses appears below.

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1. Is your firm currently involved in the installation of Solar Applications (residential or commerical)? Yes No

2. Does your firm anticipate entering into the solar energy field during the next 10 years? Yes No

3. How many specially trained solar employees do you have at this time? 1 2 3 No._____

   Note: (Trained installers tasks; mount collectors; position pumps, valves, dampers, and fans; test system operation)

4. Would you anticipate a need for trained installers within the next 10 years? Yes No

5. If answer of 4 is "yes", about how many? 1 2 3 No._____

   Note: (Trained Solar Technician: Has knowledge and skills specific to solar system design, installation, and diagnostic trouble shooting.)

6. Would you anticipate a need for Trained Solar Technicians within the next 10 years? Yes No

7. If answer to 6 is "yes", about how many? 1 2 3 No._____

Data for the 30 responding businesses is listed on the following page.

1. Yes 14 No 16

2. Yes 18 No 4 No Response 8

3. 14	businesses answered	0	0
7	businesses answered	1	7
4	businesses answered	2	8
2	businesses answered	3	6
1	business answered	5	5
2	businesses answered	6	12
			38

4. Yes 22 No 6 No Response 2

5. 4	businesses answered	1	4
10	businesses answered	2	20
5	businesses answered	3	15
1	business answered	10	10
1	business answered	15	15
1	business answered	20	20
			84

6. Yes 18 No 9 No Response 3

7. 3	businesses answered	1	3
10	businesses answered	2	20
3	businesses answered	3	9
			32

The Kansas, Plumbing, Heating and Cooling Contractors Association shows a master list of 1345 licensed shops as of November, 1979. A need of 116 solar trained people per hundred licensed shops inficate a need of 1560 solar trained people for the state of Kansas in the next ten years. This survey and assumptions have the net effect of skewing the projection toward an absolute minimum. Specifically, the assumptions ignored are:

1. The tremendous growth predicted for the solar industry.
2. A substantial cost increase of conventional fuels.
3. The fact that other businesses are persuing solar sales besides the plumbing, heating and air conditioning people.
4. Manufacturers of solar equipment and solar equipment distributors will require solar trained personnel.

Another study performed by Navarro College was approved by the Department of Energy and designed to assess manpower needs and to conduct an analysis of skills required of personnel installing, maintaining, and repairing solar devices. The study ended in January, 1978, and the results indicate the strong need for trained manpower in the emerging solar field.

Three levels of educational competency which community colleges can address are also identified in the Navarro study. For the immediate supply of manpower, there is a need for continuing education programs and seminars to upgrade conventionally trained heating, ventilating and air conditioning (HVAC)

technicians and other tradespersons in solar application. Second, a program is needed to train students in conventionally related HVAC subjects as well as solar to work primarily as solar installers/mechanics. Third, a two year associate degree program is needed to train solar technicians as diagnosticians, or para-professionals, in the solar field which will insure a continued supply of properly trained manpower for our nation's long range planning.

ASSOCIATE DEGREE

An associate Degree from an accredited community college consists of 60-70 semester hours. The philosophy of the community college is to train people in vocational/technical fields for entry-level skills. Curricula are developed by starting with the practical, objective needs for skills and ends with the theory required to understand why something is done. This is opposite from the educational concepts of four-year or graduate institutions. Community College curricula must also contain a large portion of actual laboratory, hands-on experience.

If a solar curriculum is to have widespread distribution it must be flexible enough to meet regional accreditation association criteria. Therefore, the curricula for a solar engineering technician should include 25% theory courses, 25% related and support courses, and 50% laboratory.

TASK ANALYSIS

A task analysis, a detailed listing of the steps typically performed for the design, installation, and maintenance of a solar system, is the basis used to develop a solar technology curriculum.

A. CALCULATE HOT WATER LOAD

1. Determine monthly average ground water temperature.
   a. Obtain ASHRAE Handbook or other reference, or contact water utility for temperature data. Record.
2. Determine design hot water temperature.
   a. Determine from building plans what types of appliances (e.g., dishwasher, clothes washer) are in use, and what water temperatures they require. (Consult local code books.)
3. Determine hot water requirement for persons.
   a. Using Uniform Solar Energy Code nomography or other reference, apply the number of persons using hot water to the graph and find a total hot water consumed, or multiply number of persons by 20 gallons per day.
4. Determine hot water requirement for appliances.
   a. Repeat above procedure for appliances using nomograph, or contact manufacturer or distributor of appliances for hot water demand.

5. Determine BTU requirement of monthly hot water load.
   a. Read BTU requirement from nomograph, or multiply gallons used per day by the design temperature minus the supply water temperature and by 8.3 lbs. per gallon.

PERFORMANCE OBJECTIVE

Given a hot water demand situation in the form of building plans or existing building with hot water needs, the student will obtain all information necessary and perform all calculations to determine the daily hot water heating load in BTU per day, for any locality.

B. CALCULATE SPACE HEATING LOAD

1. Determine inside and outside design temperatures and design wind speed.
   a. Look up design temperatures in ASHRAE Guide or other reference. Record.
2. Determine U-values for structure components.
   a. Determine ceiling, wall, floor, window, and door construction from plans or building.
   b. Find U-values for building materials used from ASHRAE Guide or other reference. If conductances are listed, multiply conductance per inch by thickness of material in inches to get U-value. Determine U-values of air films for still air and

15 MPH wind speed. Add reciprocals of U-values for each component and find reciprocal of total.

3. Determine areas of structure components.
   a. Measure dimensions of outside walls, ceilings, floors, windows, and walls using architectural scale of plan, or measure existing building to obtain this information, and record.
      Measure only the surfaces which represent the shell of the building.
   b. Multiply length and width to obtain area.
   c. Subtract window and door areas from gross wall areas to obtain net wall area.
   d. Sum areas of all components which have equivalent U-values.
4. Determine infiltration of structure.
   a. Multiply floor area obtained above by ceiling height to obtain volume of insulated space. Do for each room.
   b. Refer to ASHRAE Guide and multiply volumes above by appropriate factors depending on the number of walls with windows/ doors exposed to the outside. (Alternately, calculate infiltration using ASHRAE "Crack" method.) Do for each room.
5. Calculate total heat loss under design conditions in BTU/hr.
   a. Subtract outdoor design temperature from indoor design temperature $70^{\circ}F$ found in step one.

b. Multiply the area times the U-value for each building component by the design temperature differential found in step (a), and record in tabular form. Sum these values to obtain the conduction heat-loss. For infiltration, multiply the infiltration rate values from 4.b. by .018 and by the design temperature differential and add them to the conduction heat loss to obtain the design heat loss.

6. Divide design heat loss by design temperature differential and multiply by 24 to obtain heat loss in BTU/DD.

7. Determine monthly heating degree days.

   a. Find the heating degree-days for the locality under consideration in the ASHRAE Guide or from the National Climatic Center, for each month. Record.

8. Determine degree day correction factor for outside design temperature.

   a. Refer to the ASHRAE Guide.

9. Calculate monthly BTU requirement for space heating load.

   a. Multiply the heat loss in BTU per degree-day by the number of degree-days in each month. Record the monthly heating load in BTU x 10^6 or therms (BTU x 10^5).

PERFORMANCE OBJECTIVE

Given a building constructed of a variety of materials, the student will determine what references and information are required, will obtain them, and will calculate the design heat loss monthly heating load of the structure for any locale.

C. CALCULATE SPACE COOLING LOAD

1. Determine inside and outside design temperatures, latitude, and daily temperature range.
   a. Using an appropriate climatic reference (ASHRAE Handbook of Fundamentals or equivalent) consult table to obtain 97½% outdoor summer design wet bulb and drybulb temperatures, and daily temperature range for the particular location.
   b. Assume an indoor summer design dry bulb temperature of 79°F and wet bulb temperature of 62°F if indoor relative humidity is to be maintained at 50%. For other desired humidity levels, determine indoor wet bulb temperature from psychometic charts corresponding to desired humidity level and interior dry bulb temperature.
   c. From a map or other geographic reference obtain the latitude of the location.
2. Determine equivalent temperature differences.
   a. Using ASHRAE Handbook of Fundamentals, determine

equivalent temperature for each structural component with respect to surface orientation, outdoor design temperature (db) and daily temperature range.

3. Determine U-values for structural components.

   a. Method 1: If U-values for winter conditions have been previously calculated, adjust those values for changes in wind velocity and direction of heat transmission according to charts and tables in ASHRAE Handbook of Fundamentals and other comparable references.

   b. Method 2: If U-values for winter conditions have not been calculated, determine thicknesses and compositions of each portion of the structure (walls, roof, etc.). Then consult an appropriate reference to determine resistance values, conductance values, or conductivity values of each structure. Perform the mathematics to convert these values to "resistances" as required. Add the resistances of each component of the structure, making adjustments for framing per Handbook of Fundamentals as required add the interior and exterior air resistance values corresponding to the direction of heat transmission, (horizontal, vertical; up or down, etc.) and wind velocity.

Take the reciprocal of the sum of the resistances to obtain the U-value for the structure.

4. Determine areas of structure components.

   a. Procedure is identical to that specified in section B.3.a. for space heating load.

5. Determine window shading.

   a. Horizontal overhangs

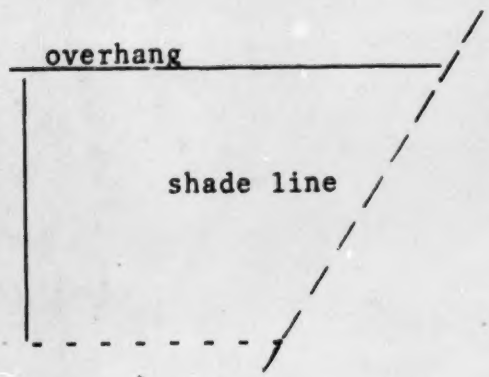
      (1) Make a table of window orientations (cardinal pts.)

N	NE	E	SE	S	SW	W	NW	
								5 a (1)
	SHADE LINE FACTOR							5 a (2)
WINDOW AREAS - SHADED								5 a (5)
				UNSHADED				5 a (6)
		S.H.G.F.						

      (2) Consult Handbook of Fundamentals and determine shade line factors for each orientation and enter into the table the corresponding orientation.

      (3) Determine the length of the overhang from building plans for each orientation.

(4) Multiply result in 5 a (3) by shade line factor for each appropriate orientation to give the position of the time-averaged shade line.



(5) Determine the area for each window and orientation that is below the shade line and the area that is above the shade line. Add the results for each window of the same orientation to give a total window area that is shaded and a total window area that is unshaded. Enter the results into the table.

(6) From Handbook of Fundamentals determine a solar heat gain factor for each window orientation according to type of window construction and interior shading devices (drapes, venetian blinds, etc.).

(7) Calculate solar heat gain by multiplying solar heat gain factor for each window orientation by the unshaded window area for the corresponding orientation. Add to that the solar heat gain through the shaded areas which is calculated by multiplying the solar heat gain factor for North orientation by the sum of the shaded window areas for all orientations.

6. Calculate internal heat gains.

a. Sensible heat gains.

(1) Gain due to occupants multiply number of occupants by 250 to give sensible load in BTU/hr. for occupancy.

(2) Gain due to appliances. Determine from building plans the types of appliances that will contribute to the internal heat gain of the structure (kitchen appliances especially). Consult Handbook of Fundamentals on other source to determine the heat gain for each appliance.

(3) Determine ventilation requirements and/or infiltration.

(a) In most cases infiltration is adequate for ventilation requirements. Assume ½ change in volume of air per hour. Calculate total volume of structure. Determine sensible gain by

multiplying infiltration rate (previous page) .018 x (ΔT_{db}) to get infiltration gain in BTU/hr.

(b) If infiltration is not sufficient for ventilation needs (refer to Handbook of Fundamentals of other reference to make this determination within the constraints of the particular problem), determine ventilation rate in CFM. Sensible gain in BTU/hr. = (1.1) (CFM) x Δt_{db}

b. Latent heat gains. For residential method, calculate total latent gain from total sensible gain for the structure (step 7).

7. Calculate total heat gains under design conditions.
   a. Sum individual sensible gains for each structure. Multiply sum by .3 to give latent gain for residential structures. (Check ASHRAE Handbook of Fundamentals to determine whether this method of calculating latent gain applies. If not, calculate latent gains independently.
   b. Total heat gain is sum of latent and sensible gains.
8. Multiply total heat gain BTU/hr. by Δt_{db} design and 24 to obtain gain in BTU/DD.
9. Calculate monthly cooling degree days.
   a. Using publication 81 of N.O.A.A. (Nat. Oceanic and Atmospheric Administration) MONTHLY NORMALS OF TEMPERATURE, PRECIPITATION AND HEATING AND COOLING DEGREE DAYS,

determine monthly cooling degree days for the particular location.

10. Calculate monthly BTU requirement for space cooling load by multiplying results of C.10, i.e. (BTU/DD), by monthly cooling degree days to give monthly space cooling load.
    a. Determining size of components; from total cooling load, total sensible load and total latent load at interior and exterior design conditions (w.b. & d.b. temperatures) consult manufacturers data on cooling units to determine required capacity of unit.

PERFORMANCE OBJECTIVE

Given a set of architectural drawings (floor plans, elevations, structural and mechanical details), for a residence which shows site orientation, necessary reference materials including ASHRAE Handbook of Fundamentals, summer design temperature and cooling degree data, architects rule and scientific calculator, the student will perform all the necessary measurements and calculations to determine the sensible and latent cooling load of the building.

D. CHOOSE COLLECTOR TYPE

1. Determine average operating collector fluid temperature.
   a. Obtain manufacturers specifications on collector performance.
   b. From collector manufacturers' specs obtain average operating collector fluid temperature that corresponds to design demands for temperature out of collector.
   c. Enter this temperature on worksheet.
2. Determine design ambient temperature and insolation.
   a. Obtain ASHRAE Handbook of Fundamentals or other source of meteorological and insolation data.
   b. Look up for design month the ambient temperature and insolation values.
   c. Enter values on worksheet.
3. Determine flat-plate and concentrating collector efficiencies for design conditions.
   a. Obtain manufacturer's specifications for collector performance.
   b. Read design conditions from worksheet.
   c. Enter performance graph on bottom axis at point defined by

$$\frac{T_{in} - T_{ambient}}{\text{Insolation}}$$

and go up to curve, then horizontally to vertical

axis and read collector efficiency.

d. Enter results on worksheet.

4. Determine cost per square foot of collector types.

   a. Obtain collector cost from manufacturers or sales outlet.

   b. Obtain effective solar absorber area from manufacturers literature.

   c. Divide cost of total collector by effective solar absorber area to get $\$/ft^2$ collector.

   d. Enter results in worksheet.

5. Calculate \$/BTU.

   a. From D.3 above enter collector efficiency and design insolation in equation below

$$\frac{\$}{BTU} = \frac{\text{Cost/Effective Area}}{\text{Insolation x Efficiency}}$$

   b. From D.4 above, enter collector cost per square foot of absorber area in equation above.

   c. Solve equation for $\frac{\$}{BTU}$

   d. Enter results in worksheet.

6. Choose collector type with lowest energy cost.

   a. From list of \$/BTU in D.5 above, choose collector with lowest \$/BTU value.

PERFORMANCE OBJECTIVE

Given manufacturers' specifications and local climatological data, the student will make the proper calculations and choose the type of collector best suited to the needs of the application.

E. CALCULATE SOLAR GAIN ON UNIT AREA BASIS

1. Determine collector tilt for application.
   a. Find local latitude from maps or atlas.
   b. Determine solar application from client or blueprints and specifications as to whether it is space heating only, water heating only, or both space heating plus water heating.
   c. If space heating only, a thumb rule for collector tilt plus 15 degrees will be appropriate to make use of the winter sun's position in the sky.
   d. If water heating only, a thumb rule for collector tilt equal to the latitude will allow year round use of collector.
   e. If combination of space heating and water heating is required, then the tilt is the same as that of space heating only.
   f. Enter results in worksheet.
2. Determine for each month average hourly insolation for tilt and latitude.

a. Obtain ASHRAE insolation tables.

b. Obtain local latitude and tilt from E.1., page 23.

c. Enter ASHRAE tables for local latitude or closest latitude for which there is a table in the month of January.

d. Read across to tilt closest to that determined in E.1., page 23.

e. Enter in worksheet the hourly values for insolation.

3. Determine for each month average ambient daylight temperature.

   a. Obtain ASHRAE Handbook or other source of temperature data.

   b. Enter table for geographic location and list average daily daylight temperature.

4. Determine monthly collector efficiency from collector performance curve.

   a. Obtain manufacturers efficiency curves.

   b. Using the following equation

$$x = \frac{T_{in} - T_{ambient}}{T_{design}}$$

   determine "x" value using design insolation, collector design inlet temperature, and ambient temperature.

c. Enter manufacturer's efficiency curves on horizontal axis at "x", move vertically to curve, then horizontally to vertical axis and read collector efficiency.

d. Follow E.4., page 24, procedure for each month of the year.

5. Determine monthly clear day collector heat gain in BTU/ft^2 -hr.

a. From E.2., page 24, sum all hourly insolation values greater than

$$\frac{125 \text{ BTU/hr}}{\text{ft}^2}$$

b. Multiply daily clear day insolation (above) by collector efficiency from E.4., page 24.

6. Determine for each month average daily daylight collection hours.

a. Obtain ASHRAE Handbook.

b. Enter tables for closest latitudes and read number of daily daylight hours.

7. Determine haze factor for locality.

a. Obtain local meteorological data from colleges, airports, Federal Government, or State Government, etc.

b. Look up haze factor for locality.

8. Determine average monthly percent of sunshine.

a. Subtract haze factor % from 100% to obtain % sunshine.

9. Calculate unit monthly solar gain in BTU/ft^2, using information obtained in E.8., page 25.

ERFORMANCE OBJECTIVE

Given the local climatological data and the manufacturer's specifications, the student will calculate the solar gain on a unit area basis.

F. DETERMINE MAXIMUM AVAILABLE COLLECTOR AREA

1. Determine roof space dimensions.
   a. Obtain blueprints or drawings (to scale) of building
   b. Using engineers or architects scale or actual on site measurement with tape measure, measure all areas of roof that give good southern exposure.
   c. Enter this area on worksheet.
2. Determine ground space dimensions.
   a. Obtain tape measure.
   b. At the site, measure length and width of ground space available for storage tank or collector placement.
   c. Enter area on worksheet.
3. Determine shaded spaces.
   a. Obtain sun angle locator box.
   b. Positioning yourself so that you are eye level with the bottom of the proposed collector array, use sun angle locator box, positioned parallel with long

axis of roof, to find time of year and position of shade devices.

c. Mark areas that will be shaded on roof/ground diagram.

d. Measure these areas.

4. Determine collector physical dimensions.

   a. Look up dimensions on manufacturer's specification sheet.

5. Allow for proper spacing of collectors on flat roof.

   a. Obtain ASHRAE Handbook.

   b. Look up solar altitude at 10:00 a.m. on December 21.

   c. On separate sheet of paper draw to scale, side view of collector array with proper tilt and collector height.

   d. Using protractor, find the point on the north side of collectors where a line drawn at an angle equal to the altitude would just touch the upper edge of the collector.

   e. Measure the distance from the back of the collector array to this point with architects or engineers scale.

6. Allow for proper collector tilt and azimuth.

7. Calculate maximum possible collector area in square feet.

   a. Subtract from gross area those areas that were not usable.

PERFORMANCE OBJECTIVE

Given blueprints or existing house and plot dimensions, the student will calculate the usable area for collector placement.

G. DETERMINE OPTIMUM COLLECTOR AREA

1. Multiply given collector area by monthly unit solar gain to obtain monthly solar gain in BTU.
   a. Obtain collector area from F.7., page 27.
   b. Obtain monthly unit solar gain from E.9., page 26.
   c. Multiply these numbers together.
2. Obtain monthly useful solar gain by taking the lesser of the monthly solar gain and the monthly total load.
   a. By looking at a column of monthly useful solar gain and a column of monthly total load, enter the lesser of the two numbers for each month in a third column.
3. Obtain the typical annual useful solar gain in M BTU by summing the monthly totals and dividing by 10^6.
   a. Add all the numbers in the third column in G.2., above.
   b. Divide this number by 10^6 to obtain M BTU.
4. Determine auxiliary fuel efficiency.
   a. Obtain written data on fuel efficiency if possible.
5. Obtain auxiliary fuel efficiency.
   a. Multiply value in G.4. above, by annual useful solar gain.

6. Determine cost of solar system.
   a. Obtain collector cost information from manufacturers.
   b. Multiply collector cost by the number of collectors to get solar collector costs.
7. Determine the mortgage interest rate and term.
   a. Obtain list of mortgage rates from local building institution.
   b. From this list determine mortgage rate based on system cost and lifetime.
8. Determine cost and inflation rate of auxiliary fuel.
   a. Obtain list or table of local utility rates.
   b. From this table determine rate which applies to the specific application (residential, commercial, etc.)
   c. Obtain from local Public Utilities Commission, estimates for fuel inflation rates.
   d. From this information determine which rate applied.
9. Calculate life cycle value of solar system.
   a. Enter data collected above in following formula:

$ = Capital cost of solar system

$ = [Capital cost of solar system including tax incentives or other factors as reflected in $/BTU] + [present value of fuel cost over lifetime of system] + [present value of stream of maintenance costs over lifetime of system]

10. Iterate previous G.9. steps with different collector areas to obtain maximum life cycle value.

PERFORMANCE OBJECTIVE

Given mortgage rates, fuel rates, and various collector areas, the student will determine the optimum collector area for the application.

H. DESIGN FLUID FLOW SYSTEM

1. Determine proper storage size and location.
   a. Locate outside tank in area protected from the elements. Locate inside tank in mech room insulated from conditioned space if used in summer.
   b. Determine application BTU/hr design load requirements from A, B, & C as applicable.
   c. Determine hours of storage required for application, typically 24 hours for heating and hot water and three to four hours for cooling.
   d. Determine BTU storage requirement by multiplying hours of storage by BTU/hr requirement.
   e. Determine design maximum storage temperature and minimum useful storage temperature.
   f. Divide BTU by the difference between maximum and minimum temperatures and divide the result by 8.33 to obtain storage size in gallons.

$$GAL = \frac{BTU}{8.33 \times \Delta T}$$

2. Integrate solar and conventional systems.
   a. For air systems, determine proper location of solar duct tie-ins. For liquid systems, determine location of water coil in conventional ductwork.
3. Design system controls and operation modes.
   a. Use two stage thermostat to bring on solar first and conventional equipment second.
   b. Use temperature sensors and relays to prevent the circulation of the solar working fluid to the load when the fluid is not hot enough to help meet the load.
   c. Use a differential control and sensors to ensure that the solar collectors recharge storage and do not degrade it.
   d. Use a motorized valve or check valve to ensure that storage is not degraded by thermal siphoning backflow.
   e. Include relief valves, air vents, vacuum breakers, and tempering valves as necessary.
4. Size individual system components in accordance with collector size and load requirements.
   a. Determine CFM and GPM for conventional equipment and solar collectors.
   b. For liquid systems, choose water coil that meets BTU/hr load requirements at design minimum useful solar supply water temperature.

c. For air systems, choose air to water exchanger to meet domestic hot water requirements at collector design CFM and outlet temperatures.

d. For liquid systems requiring a water to water heat exchanger between the collector and storage, determine collector fluid specific heat, GPM, and outlet temperature; and determine tank minimum flow over the exchanger surface and design inlet temperature. Refer to manufacturer for exchanger size.

e. Design duct and pipe sizes for required CFM and GPM not exceeding friction loss and velocity limits specified in ASHRAE handbook.

f. Choose the smallest pump and fan models that exceed or equal design CFM and GPM at required static pressure and head.

5. Prepare working drawings.

a. Determine schematic representation of system components: pipelines, valves, dampers, fans, pumps, storage, collectors, conventional equipment, etc.

b. Draw wiring diagrams linking thermostats, relays, temperature sensors, and mechanical system components.

c. Use building plans to determine physical location of components.

6. Prepare materials and equipment specifications.

a. Determine lengths of various duct and pipe sizes needed.

b. Determine number and sizes of elbows, tees, gate valves, manual dampers, registers, and other small passive

fittings for pipeline connections.

c. Determine number and sizes of motorized valves and dampers, pumps, fans, differential controls, thermostats, relays, relief valves, vacuum breakers, air vents, expansion and compression tanks, aquastats, and other small active system components.

d. Determine number and model of collectors, furnaces, air conditioning units, storage tanks, or other large system equipment.

PERFORMANCE OBJECTIVE

Given the building plans, thermal loads, and solar collector size, the student will design an energy collection and delivery system that provides adequate solar storage, efficient heat transfer, safe operation, and adequate auxiliary equipment to meet design loads.

I. CONSTRUCT STORAGE SYSTEM

1. Prepare foundation.

a. Locate site for storage container. If container is to be above grade, clear and level ground. If container is to be buried, excavate hole for storage tank, leaving enough room to inspect tank for leaks and for insulation.

b. For above grade ganks, determine size and method of mounting of tank and mark off approximate dimensions, or refer to plans for foundation dimensions.

c. Excavate footing of foundation (if required by plans or local codes).

d. Set stakes at corners of foundation and set up strings to mark of foundation, check square of foundation by measuring diagonals. Adjust string lines so that the foundation is of the proper dimensions and squared.

e. Cut form boards to coincide with string line dimensions and firmly nail corners. Set stakes around perimeter of forms. Raise form to desired level at one corner and nail to stake. Nail remainder of stakes to form, checking with level to insure the entire form is at the same level as the first corner nailed. Drive stakes at an angle (sway brace) and with inside of form lined up with string, nail stake to form. Remove string.

f. Lay down wire reinforcing mesh if required.

g. Pour concrete into form, spreading with flat shovel or concrete rake. Remove excess concrete by sliding 2 x 4 "rod" along tops of forms. Tamp concrete with tamping device such as "jitterbug". Level and fill in holes with float. Set foundation bolts (if required to secure wall plates or tank cradle). Allow concrete to set slightly and trowel with hand trowel and/or "fresno". Hand trowel to achieve finished surface.

h. After concrete has set, strip forms and remove stakes.

2. Install or construct storage container shell.

   a. (Note: It is assumed the technician will not construct the storage container, but will install a prefabricated system. There are a diversity of ways to construct storage systems for air and water systems which would require extremely lengthy discussions.) Unload storage container from delivery vehicle. If fork-lift or crane is required, insure that the tank or storage device is not subject to damage at the lifting points.

   b. Using manpower, forklift, or crane, set storage device on foundation or other prepared mounting, or in excavated hole. Bolt or otherwise secure.

3. Make connections to system.

   a. Insert threaded nipples into tank fittings (if required, applying pipe joint compound to male threads. Thread dielectric unions onto nipples (if required) and tighten with pipe wrench. (Disregard if air system.)

   b. Assemble fittings of proper size and type required to make connection between tank and plumbing stub-outs, (or duct fittings). Cut pipe or duct to appropriate lengths.

   c. Assemble fittings and pipe and double-check pipe lengths. Apply flux to cleaned pipe and fittings, re-assemble, and solder joints. (Remove rubber or plastic parts of fittings before soldering to prevent damage.) For air systems, connect duct to collars on storage tank

and tape seams with duct tape.

4. Insulate storage container.
   a. Wrap tank with fiberglass, or spray tank with foaming equipment, or laminate board insulation to tank with contact cement.
   b. If tank is to be exposed to moisture or ultraviolet radiation, wrap fiberglass insulation with plastic material and secure by banding or heat sealing, or paint foam insulation with latex sealant.

PERFORMANCE OBJECTIVE

Given a storage tank or rock storage bin, or other solar thermal storage device, the student will make the necessary preparations for the installation of the storage device. He will also recognize the method of making connections to the storage device with the help of system schematics, and will make these connections, including plumbing, ducting, and control sensors. He will be familiar with the different types of insulation, and with the proper equipment, will apply the insulation in a professional manner.

J. INSTALL COLLECTOR

1. Prepare collector mounting foundation.
   a. Mark points on roof where collector mounts are to be placed.
   b. Clean area of all loose roofing materials.
   c. Drill holes into roofing joints through roof.

d. Lay in flashing material or roofing mastic/tar or both according to plans.

e. Put collector mounting foundation in place and flash around it.

2. Construct collector mountings.

a. Obtain blueprints or plans of collector mountings.

b. Obtain material needed per plan (assess here wood mountings).

c. Attach vertical supports to foundation.

d. Attach angled supports (angle = tilt) to foundation.

e. Attach angled supports to vertical supports.

f. Attach all vertical supports together with wood members (2 x 4).

g. Paint mountings.

3. Mount each collector.

a. Obtain collectors from manufacturer.

b. Raise collector onto roof.

c. Place collector on mounting being careful not to damage copper heads or mountings.

d. Fasten collector to mounting per blueprints.

4. Install each temperature sensor.

a. Obtain thermistor or other sensing device per plan.

b. If well type temperature sensor is used, insert probe in temperature well, being careful not to damage probe.

c. If strap-on type probe is used, attach probe to collector pipe storage tank with tape or mechanical clamps insuring that sensing points are firmly touching area to be measured.

5. Connect dampers, valves, safety devices as required by system design.
   a. Obtain necessary materials (i.e. air vents, relief valves, etc.)
   b. Determine placement of air vents at all high points in system or per blueprints.
   c. Determine relief valve placement at hottest point in system.
   d. Using 3/4" copper FPT adapter, install air vents and relief valves using teflon tape on thrcads.
6. Connect manifolds and collector pipelines.
   a. Obtain blueprint and material, i.e. pipe, elbows, couplings, etc.
   b. Measure distances between collector.
   c. Cut pipe length accordingly.
   d. Clean and flux pipe (copper).
   e. Connect pipe between collector.
   f. Solder pipe fittings.
   g. Insure that pipe lines are sloped such that air vents are at high points.

PERFORMANCE OBJECTIVE

Given the proper tools and components, the student will install a collector array in such a way that it meets appropriate codes and standards and is done in a workmanlike manner.

K. COMPLETE SYSTEM HOOKUP

1. Mount major solar system components: heat exchangers, air handlers, pumps, blowers, domestic hot water tanks, etc.
   a. Select location for air handler.
   b. Construct plenum of wood or sheet metal for return air to match dimensions of air handler, or mount return air box (sheet metal) and attach collar. Install return air grill. Insulate plenum.
   c. Place or suspend air handler. If suspended, hang with sheet metal straps. If installed vertically, fasten down with screws over return air plenum.
   d. Install pumps. If 1/12 H.P. or under, support with plumbing, insuring plumbing is well anchored. If greater than 1/12 H.P., nail mounting block to suitable wall, etc. and fasten pump to block with lag or machine screws. Use dielectric unions where cast iron pump is connected to copper lines.
   e. Set domestic water heater tanks in place. If tank is placed on upper story, install sheet metal drip pan underneath.
2. Connect all solar components with pipelines as required by system design.
   a. Connect return air box (if used) to return air plenum with suitable duct material. Also connect

supply air plenum to supply boxes (boots), using Y's and appropriate sized duct. Tape all joints and insulate if not using pre-insulated duct. Set supply air registers.

3. Install conventional equipment.
   a. (Breakdown of tasks omitted since task is for non-solar equipment.)
4. Install space heating and cooling ducting. (See 2.a.)
5. Install system controls and make connections to sensors.
   a. Fasten controls to wall or other location.
   b. Connect thermostat wire from sensors to terminal strip or to control leads with wire nuts (previously described).
   c. Connect all relays, thermostats, in manner described above.
6. Flush, fill, and purge (liquid system).
   a. Fill system in manner prescribed by plans.
   b. Check all pumps to insure that they are circulating water and not cavitating as a result of air in the water lines. Bleed off air through air bleeds or by loosening fittings.
   c. Turn pumps on and off several times to insure system is free of air and that pumps are not cavitating.
7. Make electrical connections.
   a. Attach conduit to control box and to junction box (if required).
   b. Feed wire (of proper gauge) through conduit.
   c. Connect leads in junction box (insure power is off)

using wire nuts. Also connect leads at control to terminal strip or to appropriate leads.

d. Secure covers to junction box and control box.

PERFORMANCE OBJECTIVE

Given the system components to be installed, a system schematic and wiring diagrams, the student will, using the proper tools, mount all system components, and make plumbing, electrical, and other connections to the components. He will fill the system and insure that the system is entirely ready to be placed into operation. During the wiring phase, he will safeguard himself and others against electrical shock and insure his connections will not create a fire hazard, or cause damage to system components.

L. SYSTEM CHECKOUT

1. Leak test all pipelines.
   a. Inspect all joints in piping for moisture.
   b. Drain and solder any faulty joints.
2. Check out the system powered components.
   a. Insure power is delivered to system components.
   b. Place system in all possible operating modes by manually switching control and/or shorting sensor wires.
   c. Check operation of pumps, automatic valves and other components in all modes to insure their operation

complies with the intended mode of operation.

d. Return control overrides to normal position.

3. Insulate pipelines as necessary.

   a. Apply pipe insulation according to method appropriate to insulation being used (hot water pipe only).

   b. Cover, tape, or seal any insulation exposed to weather.

4. Calibrate and test solar temperature differential controls.

   a. If control system is factory calibrated, inspect operation of system under various temperature and insolation conditions. Insure that system is operating in proper modes.

   b. If control is not factory calibrated, test by immersing sensors in water at various temperatures. Monitor water temperature with thermometer and check differential on and off temperatures and high or low limit functions. Use VOM to check position of relays.

5. Test system operation modes.

   a. Observe system operation under different temperature and insolation conditions. Use overrides where necessary to simulate operation conditions.

   b. Check position of all valves and operation of pumps and relays in all modes.

6. Balance flow controls as specified.

   a. Using flow meters or collector temperature monitors, adjust flow controls to achieve balanced flow rate or uniform temperature at all collectors.

   b. Flow control valves should be wide open and then gradually closed to achieve proper balance and flow rate.

PERFORMANCE OBJECTIVE

Given test equipment, system schematics, and other tools, the student will determine that the system is operating as intended and will correct or make adjustments on the system such that it does operate correctly, or determines what components are operating in a faulty manner and require replacement or repair by specialized technicians. He will also take responsibility for completion of the system (including pipe insulation) and will place it is operating condition.

M. MAINTENANCE

1. Periodic lubrication of moving parts (pumps, blowers, etc).

   a. Locate all components requiring lubrication.

   b. Apply lubrication to components as specified by manufacturers.

2. Filter change.

   a. Remove grill or cover plate as needed.

   b. Remove old filter. Clean with air jet or replace

as recommended by manufacturer.

c. Replace filter and grill or cover.

3. Clean collector glazing.

   a. Home-owner.

4. Descale heat exchangers (water side).

   a. Remove heat exchanger by uncoupling joints or unsoldering.

   b. Flush with descaling agent.

   c. Connect flow meter and pressure gauge and check back pressure. Compare with manufacturers specs.

   d. Replace heat exchanger.

5. Flush open liquid collector loops and refill with clean solution.

   a. Drain fluid from collectors and heat exchangers.

   b. Recharge system with water and drain again.

   c. Fill system with glycol or other recommended solution or fluid.

   d. Insure all drain valves are closed and check pump to insure it is circulating through the collectors.

6. Check antifreeze solution strength and PH in liquid closed loop systems.

   a. Drain small quantity of heat exchange fluid into small container.

   b. Inspect color and/or check PH with litmus paper or test kit.

c. Check specific gravity of solution with hydrometer (if glycol used).

d. Replace fluid if necessary, or replace lost fluid.

7. Replace sacrificial corrosion elements and other system components which are periodically consumed.

   a. Drain fluid from system below level where sacrificial element is located. Insure storage tank is isolated from service water pressure.

   b. Unscrew or remove sacrificial element and replace with new element.

   c. Refill system and place in operating condition.

8. Check tracking orientation of concentrating collectors.

   a. Inspect collectors at various intervals over a day to insure that the focal point of the concentrator is on the collecting surface.

9. Check liquid levels in expansion and storage tanks.

   a. Homeowner.

10. Check normal positions of motorized valves and dampers.

    a. See L.2.

11. Monitor flowrates and temperature differentials to test system operations.

    a. Check or estimate insolation rate and check flow rate (if flow meter is built in).

    b. Monitor temperature differential across collector by attaching temperature probes to collector inlet/exit.

c. Calculate instantaneous collector efficiency and/or flow rate using manufacturer's collector performance curve and compare all results.

12. Check for degradation of pipeline insulation.
    a. Visually inspect pipe insulation exterior.
    b. Remove short section of insulation and check for moisture or deterioration.
    c. Replace insulation.
13. Check seals on pumps (for leaks).

RESOURCES

547 EASY WAYS TO SAVE ENERGY IN YOUR HOME. Albright, Roger. Charlotte, Vt: Garden Way Publishing Co.; 1978. (124 p.) $4.95.

THE SOLAR DECISION BOOK: YOUR GUIDE TO MAKING A SOUND INVESTMENT. Montgomery, Richard H.; Budnick, Jim. New York: John Wiley and Sons: 1978. (272 p.) $12.95.

THE FOOD AND HEAT PRODUCING SOLAR GREENHOUSE: DESIGN, CONSTRUCTION, OPERATION. Fisher, Rick; Yanda, Bill. Santa Fe, N. Mex.: John Muir Publications; 1976. (161 p.) $6.00.

NATURAL SOLAR ARCHITECTURE: A PASSIVE PRIMER. Wright, David. New York: Van Nostrand Reinhold Co.; 1978. (245 p.) $7.95.

THE PASSIVE SOLAR ENERGY BOOK: A COMPLETE GUIDE TO PASSIVE SOLAR HOME, GREENHOUSE AND BUILDING DESIGN. Mazria, Edward. Emmaus, Penn.: Rodale Press, Inc.; 1979. (435 p.) $10.95.

YOUR HOME'S SOLAR POTENTIAL: THE DO-IT-YOURSELF SOLAR SURVEY. Spetgang, Irwin; Wells, Malcolm. Barrington, N. J.: Edmund Scientific Co.; 1976 (60 p.) $9.95.

THE COMPLETE SOLAR HOUSE. Cassiday, Bruce. New York: Dodd, Mead & Co.; 1977. (212 p.) $8.95.

DESIGNING AND BUILDING A SOLAR HOUSE: YOUR PLACE IN THE SUN. Watson, Donald. Charlotte, Vt.: Garden Way Publishing Co.; 1977. (281 p.) $8.95

NATIONAL SOLAR ENERGY EDUCATIONAL DIRECTORY. O'Connor, Kevin. Golden, Colo.: Solar Energy Research Institute; 1979. (279 p.) $4.75.

SOLAR AGE CATALOG: A GUIDE TO SOLAR ENERGY KNOWLEDGE AND MATERIALS. Anderson, Bruce, ed. Port Jervis, N.Y.: 1977. (232 p.) $8.50.

SOLAR ENERGY EXPERIMENTS FOR HIGH SCHOOL AND COLLEGE STUDENTS. Emmaus, Penn.: Rodale Press, Inc., 1977. (129 p.) $5.95.

SOLAR ENERGY: TECHNOLOGY AND APPLICATIONS. Williams, J. Richard. Rev. ed. Ann Arbor, Mich.: Ann Arbor Science Publishers, Inc.; 1977. (184 p.) $9.95.

SOLAR HEATING AND COOLING ANALYSIS METHODS. Solar Energy Research Institute. Golden, Colo.: 1978. (10 p.). Free.

SUN-EARCH: HOW TO USE SOLAR AND CLIMATIC ENERGIES TODAY. Crowther, Richard L. et al. Denver, Colo.: Crowther/Solar Group; 1977. (232 p.) $12.95.

BUILDING A DURABLE, LOW COST SOLAR COLLECTOR. Larsen, Paul F. Loveland, Colo.: 1979. (16 p.) $3.00.

BUYING SOLAR. Federal Energy Administration. Washington, D.C.: U.S. Government Printing Office; 1976. (71 p.) $1.85.

AN INTRODUCTION TO THE APPLICATIONS OF SOLAR ENERGY. McVeigh, J.C. New York: Pergamon Press; 1977. (208 p.) $4.95.

SOLAR DWELLING DESIGN CONCEPTS. American Institute of Architects (AIA) Research Corp. Washington, D.C.: U.S. Department of Housing and Urban Development, Office of Policy Development and Research; 1976. (146 p.) $2.30.

SOLAR FOR YOUR PRESENT HOME. Barnaby, Charles S. et al. Sacramento, Calif.: California Energy Commission; 1978. (163 p.) $4.29.

PRINCIPLES OF SOLAR ENGINEERING. Kreith, F., Kreider, J.F., Washington, D.C.: Hemisphere Publishing Corporation.

SOLAR HEATING AND COOLING OF RESIDENTIAL BUILDINGS: DESIGN OF SYSTEMS. Win, C.B., et al. Solar Energy Applications Laboratory, Colorado State University.

SOLAR HEATING AND COOLING OF RESIDENTIAL BUILDINGS: SIZING, INSTALLATION AND OPERATION OF SYSTEMS. Ward, D.S., et al. Solar Energy Applications Laboratory, Colorado State University.

FUNDAMENTALS OF SOLAR HEATING. Sheet Metal and Air Conditioning Contractors National Association, NTIS, Springfield, Va. 22161.

INTRODUCTION TO ENVIRONMENTAL SCIENCE. Strahler, Arthur N., Strahler, Alan H. Santa Barbara, Calif.: Hamilton Publishing Company.

PRINCIPLES OF PHYSICS, Third Edition. Bueche, F. N.Y.: McGraw-Hill, Inc.

SOLAR ENERGY--A BIASED GUIDE. Ewers, William I. Northbrook, Ill.: Domus Books.

AUDIOVISUAL RESOURCES

FULL CIRCLE. 1978. 20 minutes, 78 slides with cassette, $85 for slides/purchase; $10 for cassette/purchase.

THE GREAT ADVENTURE. Monumental Films for the U.S. Department of Energy (DOE) Office of Consumer Affairs; 1979. 28-½ minutes, 16 mm, color, $162.50/purchase; free loan.

HERE COMES THE SUN. National Science Foundation; 1974. 15 minutes, 16 mm, color, $87/purchase; free loan.

LOOK TO THE SUN. 1977. 12-½ minutes, 16 mm, color, $69.50/purchase; free loan.

PUTTING ENERGY ALTERNATIVES TO WORK. 1977. 15 minutes, 16 mm, color, $185/purchase; $25/rental.

SOLAR ENERGY: NARRATED SLIDE PROGRAMS. Eaton, Colo.: Solar Energy Educational Service, Inc.; 1978.

SOLAR HEATING. 1977. 28 minutes, 16 mm, color, #360/purchase; $14/rental.

SUN POWER FOR FARMS. 1977. 12-½ minutes, 16 mm, color, $69.50/purchase; free loan.

SWITCH ON THE SUN. Xerox Films; 1977. 15 minutes, 16 mm, color, $270/purchase; $17/rental; $180/videotape purchase.

INSTALLING SOLAR--SOME EARLY LESSONS LEARNED. 30 minutes, 16 mm, Time-Life Multimedia, Distribution Center, 100 Eisenhower Drive, Paramus, N.J. 07652.

INSTALLING SOLAR HEATING AND DOMESTIC HOT WATER SYSTEMS. 75 slides, 35 mm, 15 minute audio cassette, P.O. Box 1607, Rockville, Md. 20850.

MEASUREMENT AND CONTROL SYSTEMS. 25 slides, 35 mm; SOLAR INSTALLATION SPECIAL TECHNIQUES. 40 slides, 35 mm, Sennergetics, 18621 Parthenia Street, Northridge, Calif. 91324.

FLAT-PLATE SOLAR COLLECTORS, Part I and Part II, videotape, 116 minutes; DESIGN AND INSTALLATION OF SOLAR HEATING AND COOLING SYSTEMS, Part I and Part II, videotape, 104 minutes; ITT/V, ITT center, Chicago, Ill. 60616.